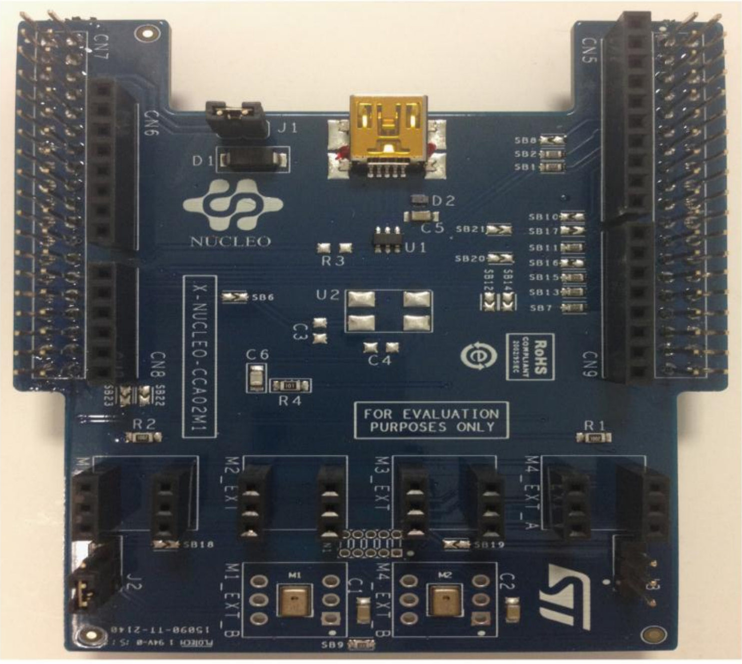
UM1900
User manual

Getting started with the digital MEMS microphones expansion board based on MP34DT01-M for STM32 Nucleo

Introduction

The X-NUCLEO-CCA02M1 is an evaluation board based on digital MEMS microphones. It is compatible with the Morpho connector layout and is designed around STMicroelectronics MP34DT01-M digital microphones. It has two microphones soldered on board and it is compatible with digital microphone coupon boards such as STEVAL-MKI129Vx and STEVAL-MKI155Vx. The X-NUCLEO-CCA02M1 allows the acquisition and streaming of up to two microphones using the I²S peripheral and up to four coupon microphones using both I²S and SPI. It represents an easy to use and fast solution for the development of microphone-based applications as well as a starting point for audio algorithm implementation.

Figure 1: X-NUCLEO-CCA02M1 evaluation board



Contents

1 Getting started

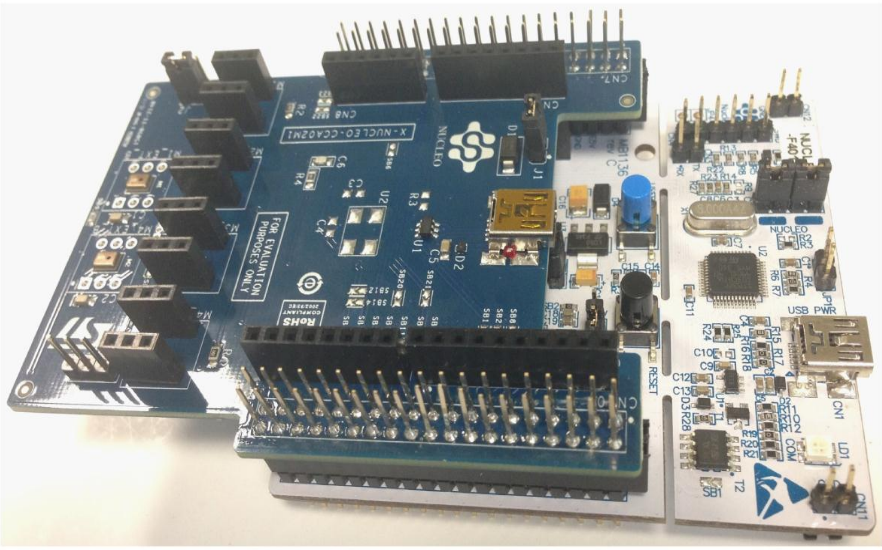
This section describes the hardware requirements for the X-NUCLEO-CCA02M1 evaluation board.

1.1 Hardware requirements

The X-NUCLEO-CCA02M1 is an expansion board for use with STM32 Nucleo boards (please refer to UM1724 on www.st.com for further information).

The STM32 Nucleo board must be connected to the X-NUCLEO-CCA02M1 board, as shown in *Figure 2: "X-NUCLEO-CCA02M1 on top of STM32 Nucleo board"*.

Figure 2: X-NUCLEO-CCA02M1 on top of STM32 Nucleo board



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The connection between the STM32 Nucleo and the X-NUCLEO-CCA02M1 is designed for use with any STM32 Nucleo board. When mounting the X-NUCLEO-CCA02M1 on the mainboard, ensure that all the pins are aligned with their corresponding connector. It is very important to handle both boards carefully during this operation to avoid damaging or bending the male/female pins and connectors.

ESD prevention measures must also be implemented to avoid damaging any X-NUCLEO-CCA02M1 board components.

2 System requirements

Using the Nucleo boards with the X-NUCLEO-CCA02M1 expansion board requires the following software and hardware:

- a Windows® (XP, Vista, 7, 8) PC for the software
- a USB type A to Mini-B USB cable to connect the Nucleo to the PC for installation of the board firmware package (order code: X-CUBE-MEMSMIC1); a utility running on the user's PC will complete the demo.

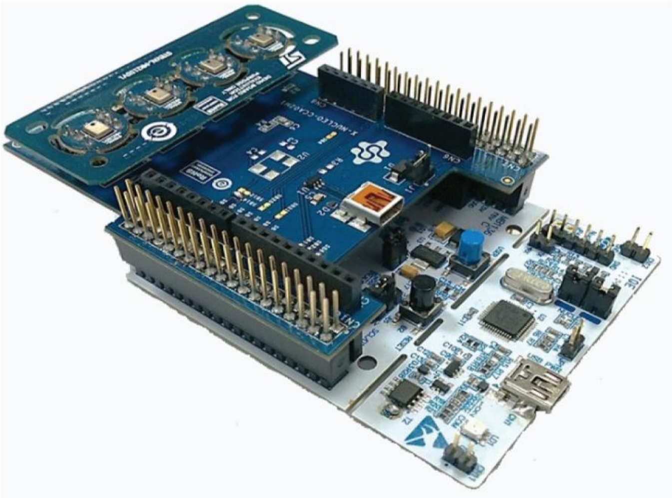
The user's PC must have the following characteristics:

- at least 128 MB of RAM
- 40 MB of available hard disk space for the X-CUBE-MEMSMIC1 firmware package and relative documentation, available on www.st.com.

3 Hardware description

The board allows the user to test the function of the STMicroelectronics MEMS microphones. For this purpose two MP34DT01-M digital MEMS microphone are mounted on the board and 6 headers (4 mounted with 2 additional footprints) are available for connecting additional microphones using digital microphone coupon boards (STEVAL-MKI129Vx or STEVAL-MKI155Vx), for further information refer to www.st.com. The connection between the X-NUCLEO-CCA02M1 and the STEVAL-MKI155V1 is shown in *Figure 3: "Connection with STEVAL-MKI155V1"*. The board interfaces with the STM32 Nucleo microcontrollers via the I²S and SPI peripherals for the synchronized acquisition of up to 4 microphones. The board also provides USB streaming using the STM32 Nucleo microcontroller USB peripheral; for this purpose, a USB connector is available as well as the footprint to mount a dedicated oscillator that can be used to feed the host MCU through the OSC_IN pin. Solder bridges are used in order to choose from different options, depending on the number of microphones and the MCU peripherals involved.

Figure 3: Connection with STEVAL-MKI155V1



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3.1 USB connector and power source

A USB connector available on the board supports audio streaming to the host PC. It can also be used to power the whole system, Nucleo board included. To enable system power sourcing from the X-NUCLEO-CCA02M1 expansion board USB connector:

- close Jumper J1 on the X-NUCLEO-CCA02M1 expansion board
- place JP5 in position E5 on the STM32 Nucleo board

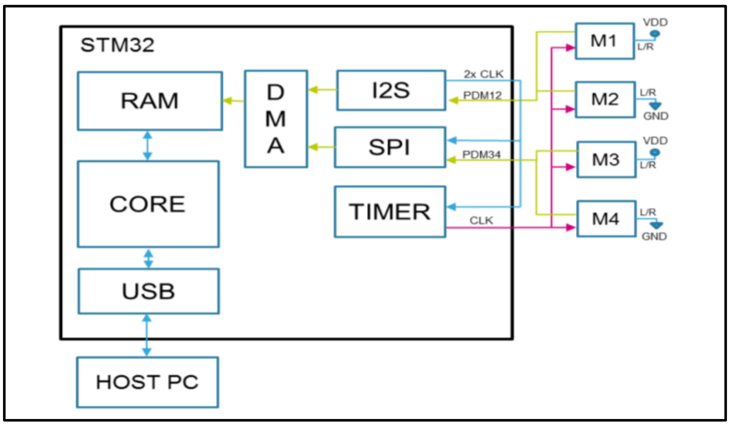
3.2 Audio acquisition strategy

A digital MEMS microphone can be acquired by using different peripherals, such as SPI, I²S or GPIO. It requires an input clock and it outputs a PDM stream at the same frequency of the input clock. This PDM stream has to be filtered and decimated in order to be in the standard PCM audio format. Two different digital MEMS microphones can be connected on the same data line by configuring the first to generate valid data on the rising edge of the clock and the other on the falling edge by setting the L/R pin of each microphone differently. On the X-NUCLEO-CCA02M1 expansion board, two microphones share the same data line and are routed to the Nucleo STM32 I²S peripheral (the first and the second microphone) and SPI peripheral (the third and the fourth).

In this scenario, microphone acquisition functions thus: a precise clock signal is generated by I^2S peripheral while SPI is configured in slave mode and is fed by the same timing signal generated by I^2S. This clock is then halved by a timer and input to the microphones: the SPI and I^2S peripherals operate at twice the microphone frequency, so that they can read data on both the rising and falling edge of the microphone clock, thus reading the bits of two microphones each. A software demuxing step is required to separate the signal from the two microphones and allows further processing like PDM to PCM conversion. *Figure 4: "General acquisition strategy block diagram"* shows a simplified diagram of the acquisition process described in this paragraph. For further information about MEMS microphone and PDM to PCM decimation, please refer www.st.com and AN3998.

For single microphone acquisition, the correct microphone timer is generated directly by I^2S and one single microphone data line is read by the same peripheral. For an example application of microphone acquisition, decimation and streaming based on X-NUCLEO-CCA02M1 board, please refer the board firmware package (order code: X-CUBE-MEMSMIC1).

Figure 4: General acquisition strategy block diagram



3.3 Solder bridges configurations

Various board configurations are possible, depending on the use cases. MEMS microphones can be connected (or disconnected) to morpho pins, and thus to MCU peripherals, using ad hoc solder bridges. Clock routing can als be changed according to specific needs. This section helps the user understand the role of each solder bridge and analyzes some of the more common use cases.

3.3.1 Solder bridges roles

In *Table 1: "Solder bridge descriptions"*, the solder bridge dunctions are summarized with respect to the audio acquisition strategies described in the previous section.

Table 1: Solder bridge descriptions

Function	Solder bridge
Connects USB D- pin to OTG_FS_DM pin on the MCU	SB1
Connects USB D+ pin to OTG_FS_DP pin on the MCU	SB2
Routes onboard oscillator output to OSC_IN MCU pin	SB6
Connect microphone clock to MCU timer output channel	SB7
Routes I^2S clock to SPI clock	SB8

Function	Solder bridge
Merges onboard microphone PDMs in order to be acquired with a single interface	SB9
Connects MIC34 PDM to MCU SPI MOSI pin	SB10
Connects MIC12 PDM to MCU I²S SD pin	SB11
Reserved	SB12
I²S clock from MCU	SB13
Connects I²S clock directly to MIC clock without passing through timer	SB14
Connect I²S clock to MCU timer input channel	SB15

3.3.2 Sample use cases

In this section, we analyze specific use cases together with the corresponding solder bridge configurations. Custom setups are also possible for ad-hoc functionalities. Note that SB1, SB2, SB6 are reserved for the USB or Oscillator pins and are not part of the audio acquisition process.

1-microphone acquisition

The I²S peripheral is used to directly acquire and give the right clock to the microphone. For this configuration, you need the following SB configuration.

Table 2: Solder bridge configuration for 1 microphone acquisition

SB	Status
SB7	Open
SB8	Open
SB9	Open
SB10	Open
SB11	Close
SB12	Open
SB13	Close
SB14	Close
SB15	Open
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open

In addition, J2 is placed in position 1-2 for onboard microphone acquisition or 2-3 for an external microphone, while J3 is left open. If using external microphones, do not plug anything in M2_EXT header.

2-microphone acquisition

As previously mentioned, this is the case in which the I²S peripheral is used to generate twice the frequency needed by the microphones. In this scenario, the clock is then halved by the timer and routed to the microphones to give them the right clock. I²S therefore reads values from both edges of the merged PDM lines. For this configuration you need the following SB configuration:

Table 3: Solder bridge configuration for 2-microphone acquisition

SB	Status
SB7	Close
SB8	Open
SB9	Open /Close
SB10	Open
SB11	Close
SB12	Open
SB13	Close
SB14	Open
SB15	Close
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open

In addition, J2 is placed in position 1-2 for onboard microphone acquisition or 2-3 for using external microphones, while J3 must is open. When acquiring onboard microphones, close SB9 to acquire both of them.

4-external-microphone acquisition

In this case, the I²S peripheral is used to generate a clock frequency that is twice the frequency needed by the microphones, and SPI is configured in slave mode in order to use such timing. As in the previous case, the clock is then halved by the timer and routed to the microphones to give the right clock. I²S and SPI read values from both the edges of the merged PDM lines. For this configuration you need the following SB configuration:

Table 4: Solder bridge configuration for 4-microphone acquisition

SB	Status
SB7	Close
SB8	Close
SB9	Open
SB10	Close
SB11	Close
SB12	Open
SB13	Close
SB14	Open

SB	Status
SB15	Close
SB16	Open
SB17	Open
SB18	Open
SB19	Open
SB20	Open
SB21	Open

In addition, J2 and J3 must be placed in position 2-3 for external microphone acquisition.

4 Connectors

The pin assignments for the Arduino UNO R3 and the Morpho connectors are shown in *Table 6: "Arduino connector table"* and *Table 5: "Morpho connector table"* respectively.

Table 5: Morpho connector table

Connector	Pin	Signal	Remarks
CN7	1	MIC_CLKx2	If SB20 is close
	3	MIC_PDM34	If SB20 is close
	6	E5V	
	12	3V3	
	16	3V3	
	18	5V	
	20	GND	
	22	GND	
	24	V_IN	
	29	OSC_CLK_OUT	If SB6 is close
	35	MIC_CLK_NUCLEO	If SB12 is close
CN10	11	MIC_CLKx2	If SB8 is close
	12	OTG_FS_DP_NUCLEO	If SB1 is close
	14	OTG_FS_DM_NUCLEO	If SB2 is close
	15	MIC_PDM34	If SB10 is close
	25	MIC_PDM34	If SB17 is close
	26	MIC_PDM12	If SB11 is close
	27	MIC_CLKx2	If SB15 is close
	28	MIC_PDM12	If SB16 is close
	29	MIC_CLK_NUCLEO	If SB7 is close
	30	MIC_CLKx2	If SB13 is close

Table 6: Arduino connector table

Connector	Pin	Signal	Remarks
CN6	2	3V3	
	4	3V3	
	5	5V	
	6	GND	
	7	GND	
	8	V_IN	
CN5	6	MIC_CLKx2	If SB8 is close
	4	MIC_PDM34	If SB10 is close
CN9	7	MIC_PDM34	If SB17 is close
	6	MIC_CLKx2	If SB15 is close
	5	MIC_CLK_NUCLEO	If SB7 is close

5 Board schematics

Figure 5: Board schematic (Part 1)

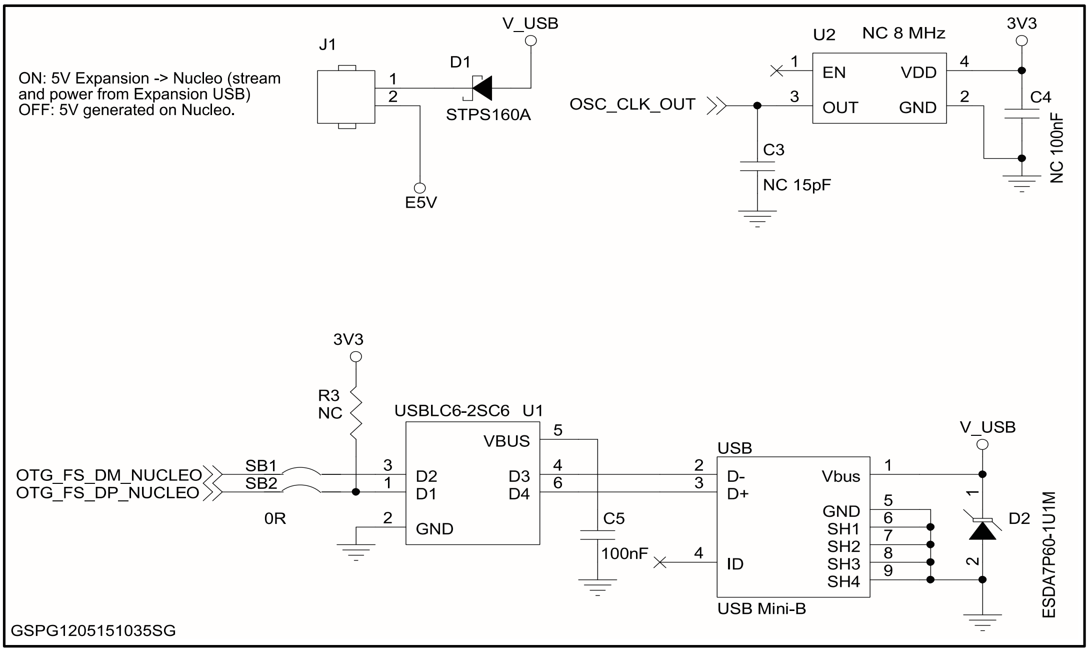


Figure 6: Board schematic (Part 2)

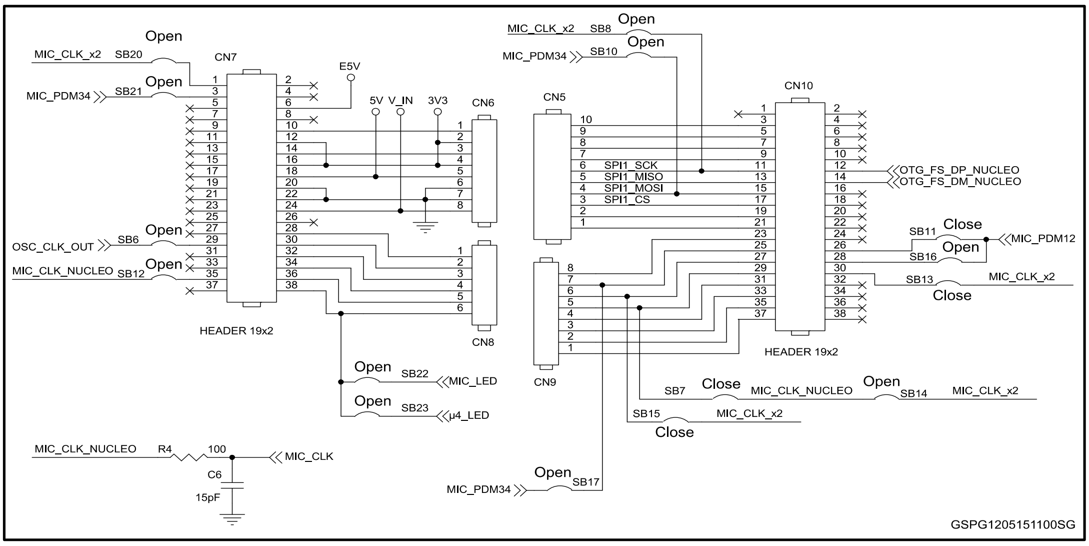


Figure 7: Board schematic (Part 3)

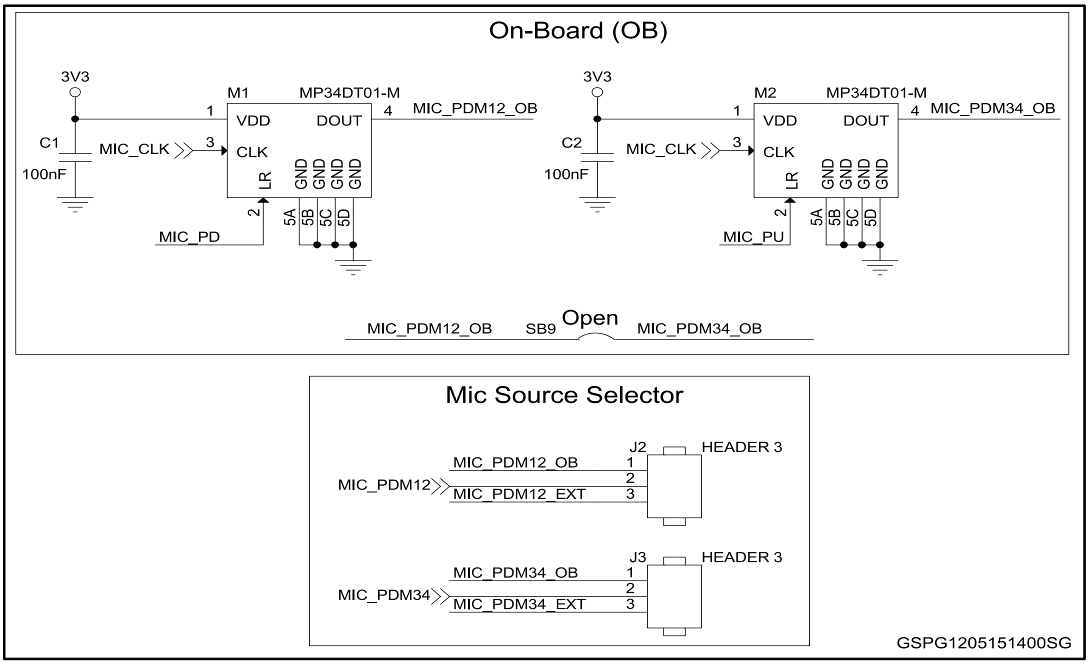
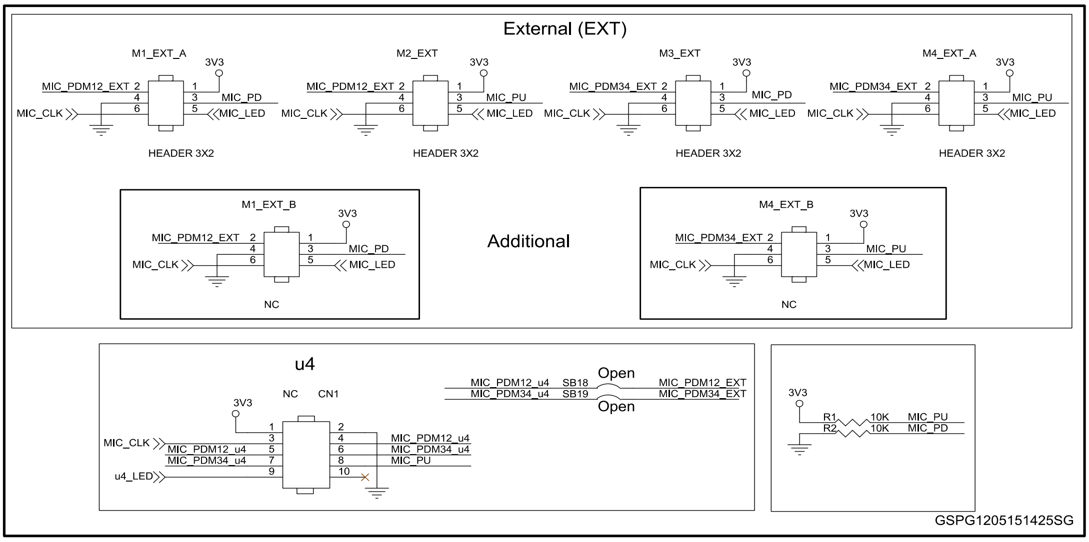


Figure 8: Board schematic (Part 4)



6 Layout

Figure 9: Top layout

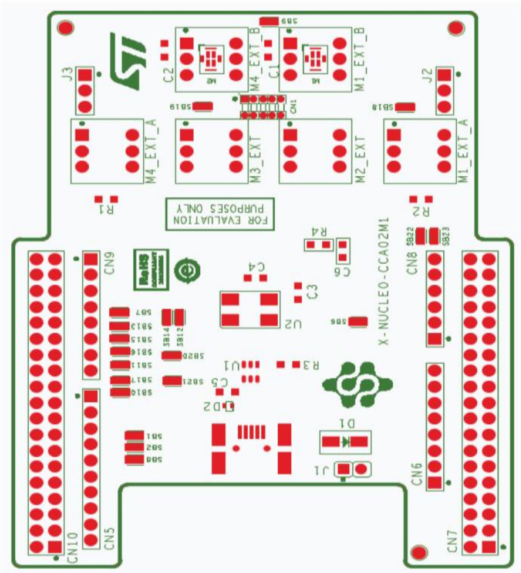
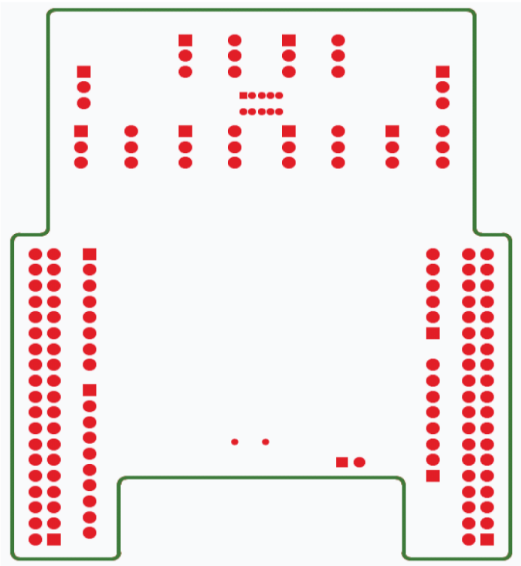


Figure 10: Bottom layout



7 Revision history

Table 7: Document revision history

Date	Revision	Changes
28-May-2015	1	Initial release.